

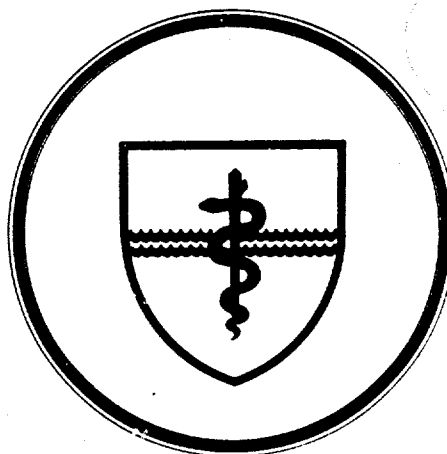
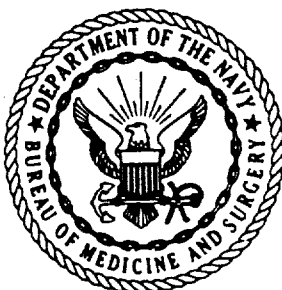
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**NAVAL SUBMARINE MEDICAL
RESEARCH LABORATORY**

SUBMARINE BASE, GROTON, CONN.

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REPORT NUMBER 939

**EFFECTS OF COLD EXPERIENCE AND TRAINING
ON ADMINISTRATION OF EMERGENCY MEDICAL TREATMENT IN THE COLD**

by

William H. Rogers, Kevin Laxar

and

George Moeller

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**Naval Medical Research and Development Command
Research Work Unit ZF51.524.013-1037**

Released by:

**R. A. Margulies, CDR, MC, USN
Commanding Officer
Naval Submarine Medical Research Laboratory**

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SUMMARY PAGE

THE PROBLEM

To lessen the decrement in performance of emergency medical treatment caused by cold-induced manual impairment and inadequate medical equipment and supplies.

FINDINGS

Neither previous cold exposure nor cold training lessened the decrement in performance of emergency medical treatment caused by cold-induced manual impairment for the conditions tested. These findings are taken as tentative until additional temperatures and durations can be tested for the exposure and training sessions. Medical equipment and supplies inadequate for use in the cold were found to contribute to the cold weather medical treatment problem.

APPLICATION

Cold weather training procedures or cold indoctrination procedures used for combat should not be altered as a result of these findings. Further research is needed. The inadequacies in medical equipment and supplies and the possible remedies mentioned herein could be considered in determination of what equipment and supplies should be included in the individual instrument and supply set carried into a cold climate by the Navy corpsmen.

ADMINISTRATIVE INFORMATION

This investigation was conducted as part of Naval Medical Research and Development Command Work Unit ZF51.524.013-1037 - Human factors analysis of emergency cold weather medical treatment. The present report is Number 1 on this work unit. It was submitted for review on 4 August 1980, approved for publication on 14 August 1980, and designated as NavSubMedRschLab Report No. 939.

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ABSTRACT

Performance of emergency medical treatment in the cold was assessed and three methods for reducing cold-induced decrements in performance investigated. Time to complete a realistic medical treatment task developed for this experiment, as well as a standard test of manual dexterity, was significantly longer in the cold (5°F) than at room temperature. Given the content validity of the medical treatment task, this confirms that aspects of Navy corpsmen's duties in cold weather are seriously impaired by the cold. The substantial correlation between the medical task scores and manual dexterity scores, combined with other evidence, suggests that loss of gross arm and hand dexterity accounts for much of the decrement in cold weather medical treatment.

Performance of both tasks significantly improved between the first two training sessions with no further improvement with practice. This one day practice effect occurred whether practice was in the cold or at room temperature. This suggests that personnel should practice the emergency medical treatment procedures they are likely to perform in the cold, and that one training session is as effective as two or three.

Two means for improving manual performance on these tasks, prior cold exposure and prior cold training, had no significant effect on cold performance. The negative results are taken as tentative, in light of the specificity of the pre-conditions tested and overriding effect of individual differences on group scores.

Finally, several equipment and medical supply inadequacies contributed to performance decrements on the medical treatment task in cold weather. Suggestions were made for correcting some of these inadequacies to improve performance in the cold.

INTRODUCTION

Most manual tasks, including those involved in military operations, are slowed by extreme cold weather. Bulky clothing, loss of manual capabilities during cold exposure, and the psychological and motivational changes that occur as a result of extreme physical discomfort, contribute to deficits in skilled manual performance in the cold. One area of military operations in which these deficits are critical is initial treatment of medical casualties in cold weather combat situations.

The emergency medical treatment of casualties in cold weather presents a unique problem for the front line combat troops and medical personnel. Operation in the cold, as compared with normal temperature, necessitates knowledge of medical procedures specific to cold injuries and the interaction of cold injuries with battle wounds. The increased risks of shock, dehydration, hypothermia and frostbite (McCarroll, Denniston, Pierce & Farese, 1977; Young, Jackson, Bynum, Wolfe, Philo, Fay & White, 1976) require increased speed and care in the initial treatment of casualties and in the transport of the casualties to a warm area.

Unfortunately, the corpsman burdened with these increased demands experiences reduced ability to meet them in the cold. Manual task performance deteriorates because of exposure of the hands to low ambient temperatures (Fox, 1967; Horvath & Freedman, 1947; McCleary, 1953; Provins & Clarke, 1960; Teichner, 1957; Vaughn, Higgins & Funkhouser, 1968); many of the tasks involved in performing emergency treatment require manipulation of supplies and equipment bare-handed or with only glove or mitten inserts. Some medical equipment and supplies are ineffective in the cold (Young, et al, 1976; Problems of medical evacuation, 1977), e.g., liquid medications freeze and bandages do not adhere. In addition, the corpsman's ability to initially inspect and treat a wound in the field is

reduced because of the danger of further exposing the wound to the cold. These factors, in the aggregate, necessitate safe, rapid methods of improving initial emergency medical treatment of casualties in cold weather combat situations.

Research to assess man's manual performance in the cold has identified several variables important in determining the degree of performance decrements experienced. Among these variables are: hand skin temperature (Fox, 1967; McCleary, 1953; Clark, 1961), ambient temperature (Fox, 1967; Horvath & Freedman, 1947; McCleary, 1953), windchill (Teichner, 1957), amount and thermal conditions of training (Clark & Jones, 1962), number, temperature and duration of previous cold exposures (Fox, 1967; Davis, 1961; Keatinge, 1961; LeBlanc, 1962; Mackworth, 1956), physical condition of the subject (Fox, 1967; Keatinge, 1961; Anderson, 1966; Heberling & Adams, 1961), and psychological variables such as motivation and attitude of the subject (Hess, 1978; Payne, 1959). In addition to the identification of these important variables, research (Fox, 1967; Vaughn et. al., 1968; Dusek, 1957) shows that different manual tasks require different degrees of finger, hand and arm dexterity, and hence are differentially affected by the cold. Thus, in determining the decrement that will be experienced in manual performance of a particular task in the cold, generalization from the decrements experienced in the performance of other tasks will have limited validity, depending on the similarity of the tasks in manual skill factors required. Elapsed time to perform an emergency medical treatment scenario (EMTS) was thus used to insure accurate assessment of the effects of cold on a corpsman's performance in a cold weather combat situation.

Research, military experience and human factor concepts suggest a number of ways in which performance of emergency medical treatment in the cold might be improved (Problems of medical evacuation, 1977). Clark and Jones (1962) conclude that over an extended training period the thermal conditions under which a manual task is practiced become part of the stimulus complex for that task. Thus subjects learn not merely to perform a task, but learn to perform it with warm or cold hands. From this it would follow that if corpsmen or combat personnel practiced medical treatment tasks in the cold, performance of those tasks in the cold would be better than if they were only practiced in normal (room temperature) thermal conditions. In current U.S. Marine Corps cold weather field exercises, field medical personnel (U.S. Navy Hospital Corpsmen) have little or no opportunity to practice treatment procedures in the cold, as their duties usually involve being on emergency stand-by for treatment of infrequent real casualties. Meaningful simulation of injuries for training purposes is rare in these exercises.

Performance on manual tasks in the cold might also be improved if subjects are simply 'exposed' to cold conditions for a period of time. 'Exposed' in this context does not necessarily mean physical exposure in the sense that individuals feel whole body cold discomfort or undergo core temperature changes. Individuals are usually fully clothed and adequately protected from the adverse effects of the cold, so 'cold experience' might more accurately describe this situation. Any physical exposure is usually local, i.e. the hands, feet or face become cold.

Whether manual task improvement via previous cold 'experience' is due to local physiological adaptation (Keatinge, 1961; Mackworth, 1956) or some sort of psychological adaptation is equivocal. Further, the amount of time that must be spent in the cold to achieve this adaptation has not been established empirically. Military operations usually proceed on the unwritten assumption that men will adapt to the cold environment in about two weeks, with adequate adaptation possible in a few days (Hess, 1978). In light of the much longer adaptation period typical of several studies (Davis, 1961; Keatinge, 1961; LeBlanc, 1962; Mackworth, 1956) which find positive evidence of local physiological adaptation, any cold tolerance increase experienced in a few days is probably due to a gain in confidence in one's ability to cope with a new and extreme environment, or some similar psychological variable. Regardless of the underlying mechanism, if such an adaptation period does in fact increase a subjects' ability to perform in the cold, then adaptation to the cold of corpsmen or other medical personnel for several days before official combat duty should reduce their performance decrements due to cold.

Finally, human factors concepts suggest that decrements in performance will occur if the equipment, supplies, materials, etc. which one must use for a task are sub-optimal for the conditions under which the task must be performed. The U.S. Navy Individual Surgical Instrument and Supply Set, carried into the field by Navy corpsmen, was not specifically designed for use in the cold, and includes supplies which are grossly inadequate for such use (Young, et. al., 1976; Problems of medical evacuation, 1977). This suggests that a full assessment of the corpsmen's supplies and equipment might lead to modifications and replacements which would ultimately improve medical treatment in the cold weather combat environment.

The present study was designed to assess the decrements in manual performance of a medical treatment task in the cold and to investigate possible methods for reducing those decrements. The Emergency Medical Treatment Scenario (EMTS) was developed for that assessment, and various experimental groups were formed to evaluate alternative methods of improving performance. In the control group, subjects received neither cold exposure nor cold training prior to performance tests in the cold. To evaluate Clark and Jones' (1962) condition-specific training hypothesis, another group of subjects was cold trained and, hence, cold adapted on several days prior to performance tests in the cold. To provide a cold exposure control for the training group and to determine the ameliorative effects of short exposures on subsequent performance, a third group of subjects spent the same amount of time in the cold as the training group prior to performance testing in the cold, but did not practice the tasks in that environment. All three groups were equated for amount of training on the task. If the environment and hence, cold hands, indeed become an integral part of the task, then the group which practiced in the cold should perform better on subsequent tests in the cold than the other groups, which did not practice in that environment. If a few short cold exposures prior to testing cause physiological adaptation or a gain in confidence or some similar psychological adaptation which positively affects performance, then the group that received cold exposure prior to testing should perform better than the control group which did not.

Lastly, equipment and supplies used in a medical treatment task in the cold were evaluated for inadequacies, and recommendations were made for modifications or replacements which would lead to better manual performance.

METHOD

Subjects

Seventeen U.S. Marine Corps and 1 male U.S. Navy Hospital Corpsman, stationed at the U.S. Naval Submarine Base in Groton, CT, volunteered for this experiment. Subjects ranged from 18 to 26 years in age, with an average of 16 months in the service. Three Marines had prior cold weather field experience; one of those also had been instructed in cold weather medical treatment. Another Marine had cold weather medical treatment instruction, but not field experience.

Subjects were tested in three replications. Within each of these replications six subjects were randomly divided into three groups, two subjects per group. The control group had neither cold exposure nor cold training prior to the test day, the training group trained in the cold each day, and the exposure group was exposed to the cold each day of the experiment, but trained at room temperature until the test day.

Four subjects did not complete the experiment. Two discontinued testing after one trial on the final test day because of extreme hand discomfort due to the cold. Both subjects had been assigned to the control group. Two other subjects dropped out with upper respiratory infections, one after the first practice, the other after the second practice. One subject had been assigned to the cold training group and the other to the cold exposure group. Thus, four subjects from the control group, five from the cold training group, and five from the cold exposure group completed the experiment.¹

Materials

Testing was done either inside a 15 foot (4.57m) long by 12 foot (3.66m) wide by 9 foot (2.74m) high cold chamber at the Naval Underwater Systems Center, New London or in an area outside the chamber in the same building. The chamber was maintained at 5°F (-15°C) for the testing sessions.² A fan inside the chamber run as part of the cooling system made the effective temperature approximately -2°F (-19°C) during testing. The range of temperatures outside the chamber during testing was 68°F (20°C) to 80°F (27°C). The experiment was run in mid-summer so subjects were not acclimated to the cold.

The simulated casualties for the EMTS were two mannikins approximately equal in size and density to an adult male, weighing 77.1 kg fully clothed in cold weather gear, and measuring 175 cm in height. Subjects used the U.S. Navy Individual Surgical Instrument and Supply Set (see Appendix A for kit contents) for the EMTS task. The commercially available Minnesota Rate of Manipulation (MRM) test board was used for the two-handed turning subtask of the MRM test series. Subjects and experimenters wore standard U.S. Marine Corps cold weather gear (pants with long underwear, hooded jacket with liner, gloves, wool glove inserts, cold-weather boots) in the cold chamber. Outside the chamber subjects wore the gloves and glove inserts, but did not wear any of the other cold weather clothing. The MRM test was performed bare-handed, whether in cold or room temperature conditions. Standard U.S. Marine Corps cold weather sleeping bags were used as evacuation bags for the EMTS.

Tasks

The EMTS, consisting of ten subtasks, and the two-handed turning task of the MRM test were administered during the experiment. The MRM task was included because of its reliability in measuring factorially 'pure' gross arm and hand dexterity (Rim, 1962) and its sensitivity to the effects of cold (Teichner, 1957; Dusek, 1957) and other extreme environments (Moeller, Chattin, Rogers, Laxar, & Ryack, in press). The MRM was also included to test our hypothesis that manual dexterity figures importantly in EMTS performance. Since the latter was developed for this experiment and had not been tested previously, use of the MRM guaranteed that at least one reliable measure would be obtained.

The EMTS was developed and used to require abilities which would actually be needed by medical personnel in a cold weather combat situation. This scenario was developed in collaboration with experienced corpsmen and cold-weather medical experts and was considered by all to simulate very closely the emergency medical treatment that a Navy corpsman or Marine might be required to perform in a cold weather field situation. The task was purely a treatment scenario, as the inclusion of patient examination and injury diagnosis, which involve complex decision making processes, would have endangered the standardization of the task. The task was designed to evaluate as many items of the Individual Surgical Instrument and Supply Set as possible and to test several items of the kit which had been previously identified as potential problems in the cold, such as adhesive tape, scissors and wire mesh splints. The EMTS was procedurally refined in a number of pilot runs with Navy corpsmen assigned to the Naval Submarine Medical Research Laboratory, Groton, CT.

The ten steps of the EMTS involved the following: 1) unrolling and unzipping a sleeping bag, and setting it up as a temporary windbreak for the casualty; 2) removing a pressure bandage from the kit and unfolding it in preparation for application; 3) applying the pressure bandage to a simulated leg wound; 4) removing a wire mesh splint from the kit, and unrolling and shaping it in preparation for application; 5) removing adhesive tape or gauze from the kit, and cutting and laying out three strips for securing the wire mesh; 6) securing the wire mesh to a fractured arm; 7) removing a shoe and sock to simulate inspection of possible frostbite; 8) replacing the shoe and sock loosely to protect the foot from further damage; 9) placing the casualty in an evacuation bag and zipping the bag closed; and 10) filling out a standard U.S. Field Medical Card on the casualty's injuries and treatment.

Procedure

The six subjects of each replication practiced the tasks on a Monday, Tuesday and Thursday, and were tested on Friday. The subjects were not available on Wednesday. The three days of practice were procedurally identical and involved the following for all subjects: three trials of the EMTS and six (two sets of three) trials of the MRM performed in the sequence EMTS-MRM-EMTS-MRM-EMTS. The two subjects of each replication assigned to the same experimental group alternated trials on each task such that S1 performed trial 1 of the EMTS and one set of MRM trials while S2 observed, then S2 performed trial 1 of the EMTS and one set of MRM trials while S1 observed, etc. The subject that began the trials first in practice 1 started the trials second in practice 2, and first again in practice 3. The inter-trial interval (ITI) for each subject was the time it took the other subject in the pair to perform the EMTS and a set of MRM trials.

Control subjects performed all tasks during practice outside the cold chamber at room temperature and at no time prior to the test day were they exposed to the cold. While control subjects performed the tasks outside the chamber, all other subjects were exposed to the cold condition. Four subjects, two each from the cold training and cold exposure groups, would enter the chamber simultaneously to cold soak for 30 minutes at -15°C . The two cold training subjects would then begin practice in the cold following the procedures described above. The cold exposure subjects were passive observers but would generally assist the experimenters in repacking the medical kit and preparing the mannikins for the next trial. All four subjects would leave the chamber simultaneously thus having equal exposure time.³ Cold exposure subjects were given 30-45 minutes to warm up and then were practiced on the tasks outside the chamber as had the control subjects.

On test day, tasks were performed by all subjects inside the chamber at an effective temperature of -19°C . The six subjects of a replication were randomly divided into test pairs, with the restriction that two subjects from the same experimental group could not be assigned to the same test pair. The members of a test pair entered the chamber and performed the tasks simultaneously. The testing sequence of tasks on the test day was the same as in practice. Each experimenter scored all EMTS trials on one mannikin and subjects alternated trials on mannikins so that all trials for a subject were not scored by the same experimenter. The pairs of subjects entered the chamber at 20-minute intervals and all subjects cold soaked for 30 minutes before testing. Test pairs alternated trials, so the ITI was the time it took two subjects, one from each of the other pairs, to complete the EMTS task and 1 set of MRM

tests. A test pair was allowed to leave the chamber as soon as both members completed the third EMTS trial. This procedure equated total exposure time for all participants.

RESULTS

The mean scores of the three groups on the EMTS and MRM tasks for the practice days and test day are shown in Figures 1 and 2. Since the control group and the cold exposure group practiced and were tested under the same thermal conditions, their data for the practice and test days were analyzed together. Groups x trials x days analyses of variance were computed for the EMTS and MRM tasks, 2x3x4 and 2x6x4 respectively. For the EMTS task there was a significant day effect, $F(3,24) = 5.46$, $p < .01$, a significant trial effect, $F(2,16) = 17.87$, $p < .01$, and a significant trial x day interaction, $F(6,48) = 9.26$, $p < .01$. A Newman-Keuls a posteriori test showed that Day 1 performance was significantly slower than Day 2 ($p < .05$) and Day 3 ($p < .01$), and that Day 4 performance was significantly slower than Day 3 performance ($p < .05$). A Newman-Keuls test of the trial effect showed that performance on the first trial was significantly slower ($p < .01$) than performance on the second or third trials. The trial x day interaction (see Figure 3) was due to a much greater improvement over trials on Day 1 than on the other days reflecting the greater learning increment early in practice.

For the MRM task there was a significant day effect, $F(3,24) = 7.36$, $p < .01$, and a significant trial effect, $F(5,40) = 12.63$, $p < .01$. A Newman-Keuls test showed that Day 1 performance was significantly slower than Day 2 or Day 3 ($p < .05$) performance, and Day 4 performance was significantly slower

Figure 1. Mean EMIS scores on practices (Days 1-3) and cold test (Day 4)
for control, training and exposure groups.

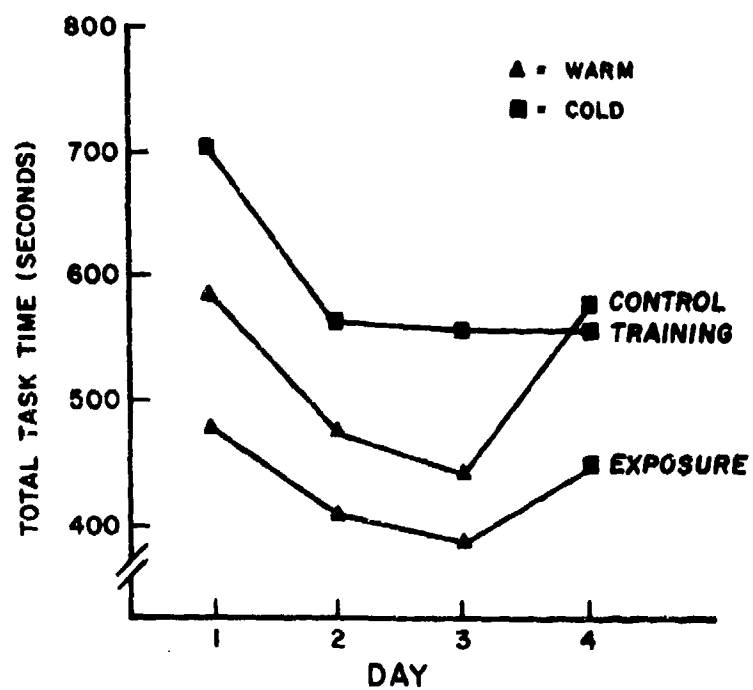


Figure 2. Mean MRM scores on practices (Days 1-3) and cold test (Day 4) for control, training and exposure groups.

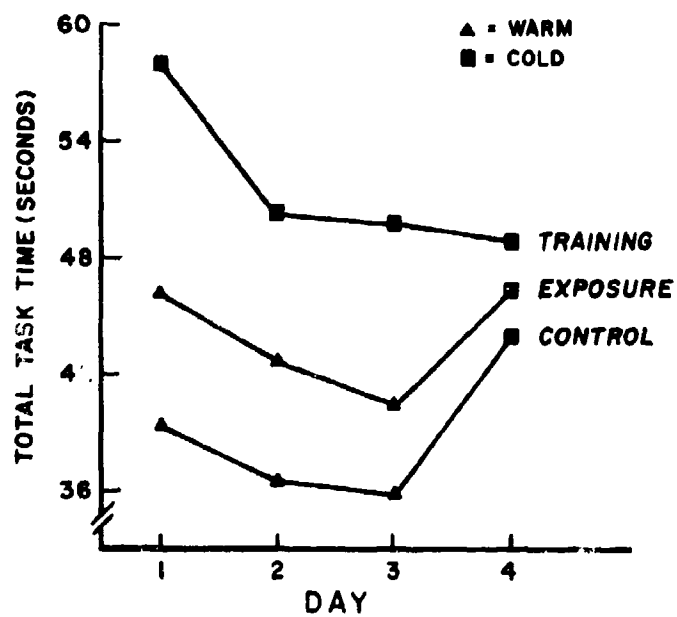
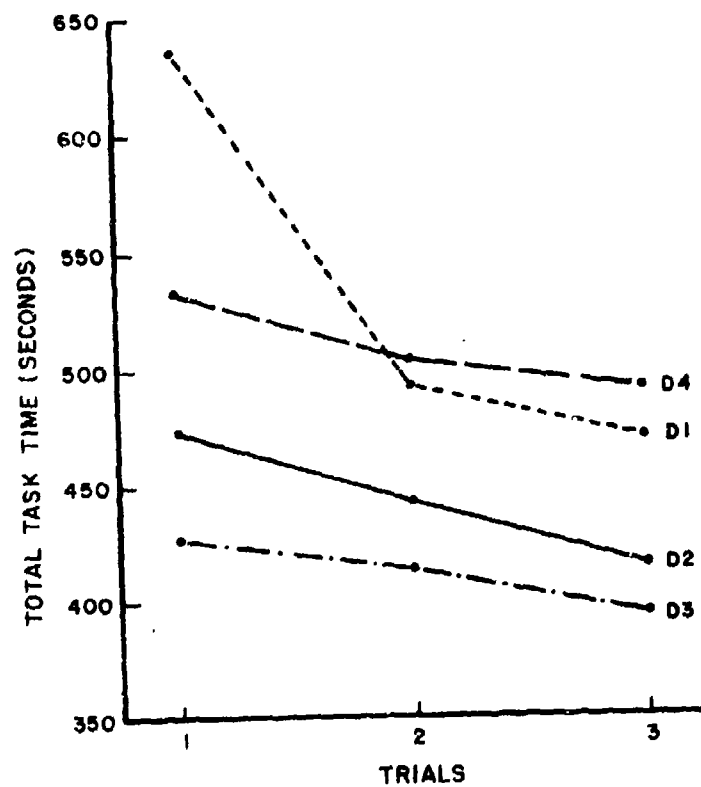


Figure 3. EMTS task, control and exposure groups - day x trial interaction.



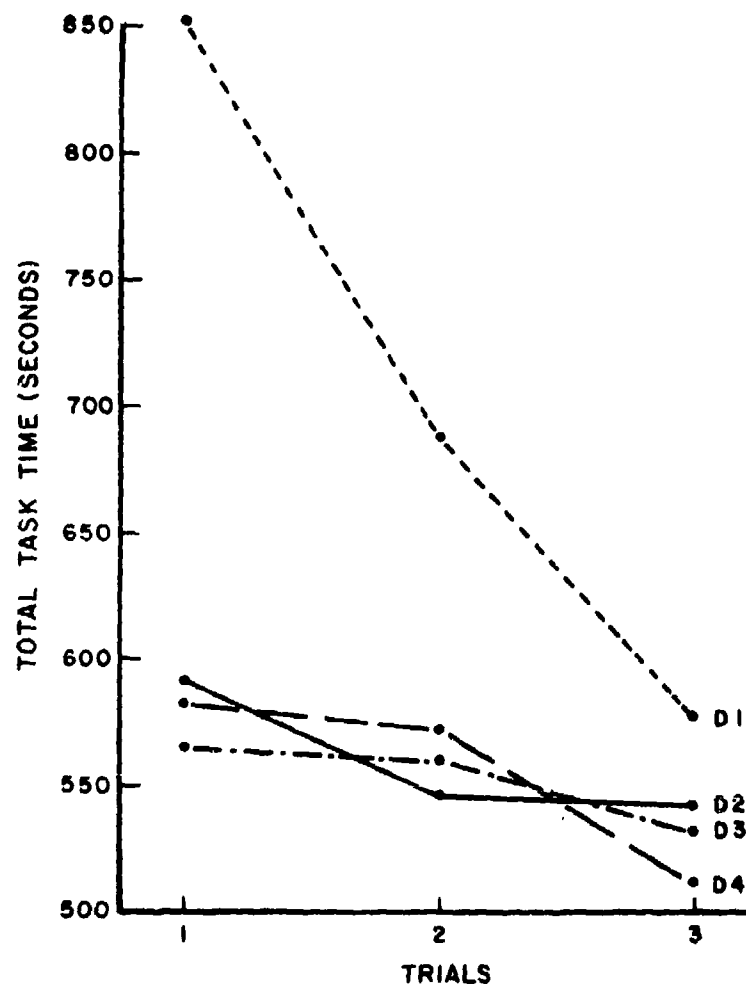
than Day 2 ($p < .05$) and Day 3 ($p < .01$) performance. A Newman-Keuls test of the trial effect showed that Trial 1 performance was significantly slower than the performance on Trials 2-6 ($p < .01$) and that Trial 6 performance was significantly faster than performance on Trials 1-4 ($p < .01$). No other significant effects were found with these analyses.

For the cold training group, trials x days analyses of variance were computed for the EMTS and MRM tasks, 3×4 and 6×4 respectively. For the EMTS task there was a significant day effect, $F(3,12) = 9.99$, $p < .01$, a significant trial effect, $F(2,8) = 20.05$, $p < .01$, and a significant trial x day interaction, $F(6,24) = 5.97$, $p < .01$. A Newman-Keuls test showed that Day 1 performance was significantly slower than performance on Days 2-4 ($p < .01$). A Newman-Keuls test on the trial effect showed that Trial 1 performance was significantly slower than Trials 2 and 3 ($p < .05$). The trial by day interaction (see Figure 4) was due to a much greater improvement over trials on Day 1 than on the other days, again reflecting greater learning early in practice.

For the MRM task there was a significant day effect, $F(3,12) = 6.52$, $p < .01$. A Newman-Keuls test showed that performance was significantly slower on Day 1 than Day 2 ($p < .01$), Day 3, and Day 4 ($p < .05$). No other significant effects were found with these analyses.

Analyses of variance (3 groups x 3 trials) were computed for the cold test scores (Day 4) from each of the 10 subtasks of the EMTS, and for the total time to complete the EMTS. No differences were found among the groups. A significant main effect of trials was found for: the ninth EMTS subtask (putting the patient in the evacuation bag), $F(2,24) = 4.57$, $p < .05$; the

Figure 4. EMTS task, training group - day x trial interaction.



tenth EMTS subtask (filling out the medical card), $F(2,24) = 8.23, p < .01$; and total time for EMTS, $F(2,24) = 6.62, p < .01$. Each of these trial effects was due to performance improvement with repeated trials. No other significant effects were found for any of the EMTS subtasks or for a Groups x Trials analysis of variance for the MRM scores.

A correlation matrix was computed for Day 4 scores for the 10 subtasks of the EMTS, and the total time for the EMTS and MRM (see Table 1). The internal consistency of the EMTS was demonstrated to be high by the significant correlations of each of the subtasks of the EMTS except subtask 2 (preparing the bandage) with the total time to complete the EMTS. A significant correlation was also found between the EMTS total time and the MRM scores.

DISCUSSION

The significant decrements in performance during the cold test in comparison with those during the last practice at room temperature for the control and cold exposure groups confirm that both EMTS and MRM performances were impaired by conditions imposed on the fourth day (Table 2). While these decrements could be due to impairment caused by additional clothing rather than cold-induced manual impairment, a post-test questionnaire administered to the subjects supports the manual impairment hypothesis. Subjects were asked if they thought that the cold weather clothing had impaired their performance of the tasks in the cold. While 12 of the 15 subjects responded yes, 9 of the 12 said the gloves were the only or the primary source of clothing impairment. Gloves were worn by the subjects performing the EMTS at room temperature as well as in the cold so it is unlikely that gloves accounted for the Day 4 decrement. Gloves were not worn for the MRM task and therefore were not a factor in the MRM performance decrement.

Table 1

Correlation Matrix of Time to Complete 10 EMTS Subtasks, Total EMTS, and MRM

| Variables 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-----------------------------|-----|-----|------|-------|------|-------|-------|-------|-------|-------|-------|
| 1 Wind break | .35 | .42 | .49 | .48 | .29 | .41 | .27 | .57* | .46 | .66** | .48 |
| 2 Prepare bandage | | .09 | .53* | .63** | .12 | .50* | .14 | .31 | .17 | .36 | .43 |
| 3 Apply bandage (leg) | | | .53* | .46 | .54* | .55* | .58* | .44 | .56* | .74** | .47 |
| 4 Prepare wire mesh | | | | .62** | .27 | .67** | .41 | .56* | .47 | .78** | .66** |
| 5 Prepare splint fastenings | | | | | .13 | .54* | .21 | .32 | .21 | .62** | .52* |
| 6 Apply splint (arm) | | | | | | .34 | .67** | .39 | .59* | .62** | .16 |
| 7 Remove sock and boot | | | | | | | .48 | .64** | .44 | .77** | .67** |
| 8 Put sock and boot on | | | | | | | | .53* | .81** | .74** | .35 |
| 9 Place in evacuation bag | | | | | | | | | .57* | .78** | .56* |
| 10 Fill out medical card | | | | | | | | | | .79** | .42 |
| 11 Total Time EMTS | | | | | | | | | | | .66** |
| 12 Total Time MRM | | | | | | | | | | | |

1. Correlations were computed using 45 scores, 3 trials for each of 15 subjects. For determining significance levels, $df=14$

* $p < .05$

** $p < .01$

Table 2

Mean time to complete tasks (sec) on Days 3 and 4 and performance decrement due to cold for control and cold exposure groups.^a

| Task | Day 3 | Day 4 | Cold Decrement (Day 4-Day 3) |
|-------------------|-------|-------|------------------------------------|
| EMTS ^b | | | |
| Control | 438.9 | 574.0 | 135.1 |
| Exposure | 387.3 | 446.7 | 59.4 |
| MRM ^c | | | |
| Control | 36.0 | 43.9 | 7.9 |
| Exposure | 40.4 | 46.4 | 6.0 |

^a Means computed for five subjects per group

^b Emergency Medical Treatment Scenario

^c Minnesota Rate of Manipulation Test, 2-handed turning task

Four subjects said the hood of the jacket impaired their vision and two said the bulkiness of the jacket impaired their movement, but in light of the low frequency of these responses and experimenter observations, it is concluded that clothing was not the major factor in the Day 4 decrement.

Further, in responding to questions regarding the effect of cold on their performance of the tasks and on their thermal comfort, 12 of the 15 subjects responded that the cold slowed down their performance of the tasks and 14 of the 15 said that their hands were cold during the experiment. None responded that they experienced whole body chilling, while four subjects said their face was cold and two said their feet were cold. The hands were obviously the areas most affected by the cold. The reliability of the MRM test for measuring gross arm and hand dexterity coupled with the high performance similarities over days and trials for the EMTS and MRM tasks and the significant correlation between them on Day 4, suggest that the EMTS task is also measuring, to some degree, gross arm and hand dexterity.

Thus, it is concluded that the delays encountered in performing the EMTS in the cold were due primarily to cold-induced manual impairments, gross arm and hand dexterity in particular. The EMTS was performed 24% more slowly in the cold (-15°C) than at room temperature. Since other sources of task impairment such as snow and enemy fire were not simulated in this experiment, this quantification of the cold decrement due primarily to manual impairment is a good estimate of the minimum time delays that will be met in emergency medical treatment at this temperature in the field, and provides a conservative measure of the seriousness of the cold weather emergency medical treatment problem.

The significant difference between Day 1 performance and the other practice days for all groups on both tasks (see Figures 1 & 2) reflects the improvement in task performance due to practice. The lack of difference between practice Days 2 and 3 for the control and cold exposure groups and Days 2, 3, and 4 for the cold training group suggests that little improvement due to practice occurred after Day 2. Consequently, Navy corpsmen or combat personnel should practice the emergency medical treatment procedures they are likely to perform in the cold, and one training session is as effective as two or three. The trials effects found in all analyses were probably due to a warm-up effect on all days, and the trials by days interactions due to the combination of a practice effect on Day 1 and the warm-up effect on all days.

The lack of main effects due to experimental groups on Day 4 or significant interactions of experimental groups with trials or days for any of the tasks in any of the statistical analyses argues against the hypotheses that either prior cold exposure or prior cold training enhance subsequent cold weather manual performance. These negative results must be taken as tentative, however, for it might be that the cold exposure and cold training sessions used in the present experiment were too brief and too few in number to have a facilitating effect on subsequent performance in the cold. Though anecdotal evidence claims that a few days cold exposure will lead to improved performance in the cold, a longer period of each day might need to be spent in the cold conditions than tested in the present study. Further, Clark & Jones' (1962) condition-specific training effect only manifested itself after two weeks of training. They actually obtained a short-term result similar to the present results, i.e. after one training session performance in the cold was equivalent for two groups, one trained with warm hands and one trained with cold hands. Thus, more extended cold exposure and cold

training sessions need to be tested before the results of this experiment can be generalized.

While there were large differences in the mean total time for each group to complete the EMTS (Control = 573.9 sec., Training = 557.6 sec., and Exposure = 446.7 sec.) on the test day, the much longer completion times of the control and training groups were due primarily to one individual within each group.⁴ The subject whose performance greatly increased the mean time for the control group seemed to be more sensitive physiologically to the cold than the other subjects.⁵ This suggests that even in the absence of general improvement in cold performance through prior cold exposure or cold training, these pre-test procedures might be justified for their ability to screen individuals particularly sensitive to the cold. The individual whose performance greatly increased the mean time for the cold training group performed the EMTS task on the test day about two minutes slower than he had on a prior day when he practiced in the cold. This indicates that the level of performance decrement on the test day was not solely due to the cold temperature. It is likely that motivational or attitudinal variables deteriorated performance to a level below that obtained in prior practice under the same conditions.

These two cases illustrate the individual difference problem almost inevitably encountered in investigating performance in extreme environments (Fine & Kobrick, 1978). A modest effect of cold exposure or cold training might become statistically 'hidden' by substantial within-group variability due to individual differences, or the effects might be ameliorative only for some individuals, and deleterious or null for others. Subjects' level of physical cold sensitivity and motivational and attitudinal profiles should be considered in future research.

The human factors evaluation of the U.S. Navy Individual Surgical Instrument and Supply Set for use in cold weather revealed several problem areas. First, inclusion of adhesive tape in the supply kit for cold weather combat is considered inappropriate. In splinting the arm, the tape did not stick at -15°C , resulting in a poorly fastened splint, and the subtasks involving the use of the tape were performed 21 sec. slower on the average than were those same subtasks when cloth gauze was substituted for the adhesive tape. This was despite the fact that the cloth gauze had to be cut with scissors, and tied to secure the bandage.

Fastening the splint with either the tape or the gauze was extremely difficult to perform with gloves. This points to another problem, i.e. the difficulty of manipulation of many of the supplies while wearing gloves. The subjects in these experiments wore the standard wool inserts and thin black leather outer gloves. In colder weather, the heavier, more bulky arctic mittens would be worn, making the removal of the handwear a necessity for more aspects of the task. Difficulty was encountered in the present experiment with the following manipulations: closing the medical kit; zipping and unzipping the sleeping bag; tying bandages; cutting with scissors; removing bandages from their packages; and filling out the medical card. Some of these manipulation problems would appear to have simple remedies: Velcro could be tested as a replacement for the snaps on the medical kit; zippers on cold weather sleeping bags could be plastic rather than metal and have oversized zipper tabs; scissors could have oversized finger holes; and oversized pencils could be used to fill out the medical cards.

The manipulation problems in general have historically been tackled, with only limited success, through the development of special gloves which provide more adequate insulation yet allow more fine finger dexterity than the standard issue gloves. While current efforts at developing heated handwear are being strongly encouraged (Problems of medical evacuation, 1977), the low success rate of such endeavors suggests that research directed at modifying the manipulanda for use with heavy gloves should continue concurrently.

Additionally, problems were encountered with the lead falling out of the mechanical pencils, suggesting that regular or Carpenter's lead pencils might be advantageously substituted for the mechanical lead pencils. The glass aspirin bottles in the medical kit broke confirming the need for more suitable packaging (Problems in medical evacuation, 1977). The wire mesh used for splints was difficult to unroll and shape with cold hands. Further, if the mesh splint is placed in direct contact with the patient's skin, the cold metal adds to the risk of frostbite or frostnip. If the mesh is placed over the patient's clothing, then the sharp edges of the wire have a tendency to rip the evacuation bag when the patient is placed in it. In light of the equal or greater inadequacy of pneumatic splints in the cold (Problems of medical evacuation, 1977), other splinting materials should be tested for use in the cold. Alleviation of these equipment and supply inadequacies would definitely lessen the performance decrements caused by cold-induced manual impairment, and should, therefore, be given primary consideration in the search for methods of improving emergency medical treatment in the cold.

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FOOTNOTES

- 1 Analysis of variance tests were computed for five subjects per group. Missing data for one subject in the control group were estimated from the trials which he completed.
- 2 Temperature inside the chamber was continuously recorded on a strip chart recorder. Besides momentary localized fluctuations when a small door was opened, the chamber temperature remained constant within a 2°F range.
- 3 The average exposure on practice days was 2 hours, the shortest exposure being one hour forty-five minutes and the longest exposure being two hours twenty minutes.
- 4 Statistical results did not change when these two subjects were omitted from the analyses.
- 5 This was one of the two subjects who was unable to complete testing because of extreme hand discomfort due to cold.

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APPENDIX A

INDIVIDUAL SURGICAL INSTRUMENT & SUPPLY SET

| Item | Quantity | Used in EMTS |
|---|------------|--------------|
| Case, Medical Instrument & Supply Set, Nylon Non-rigid No. 3, 10" long x 4½" wide x 8" high | 1 | ✓ |
| Wire Fabric, 5½ x 36 inches | 1 Roll | ✓ |
| Aspirin Tab, USP, 0.324 gm 5 gr, 100s | 2 Bottles | |
| Povidone-Iodine Solution, NF 10%, 1/2 Fl oz (14,8cc) 50s | 3/50 Box | |
| Tetracaine Hydrochloride Ophthalmic Solution 0.5%, 15cc | 2 Bottles | |
| Atropine Injection, 1cc, 12s | 2 Packages | |
| Dressing, First Aid, Field, Individual Troop, Camouflaged 4"x7" | 8 | ✓ |
| Bandage, Gauze, Camouflaged 3 in x 6 yds | 2 | ✓ |
| Bandage, Muslin, 37x37x52 in | 2 | |
| Dressing, First Aid, Field 7½ x 8 inches | 2 | |
| Adhesive Tape, Surgical, 3" x 5 yds | 1 | ✓ |
| Bandage, Absorbent, Adhesive, ¾ x 3 in., 300s | 36/300 Box | |
| Tourniquet, Nonpneumatic, Camouflaged, 1½ x 42 inches | 1 | |
| Airway, Pharyngeal, Child | 1 | |
| Airway, Pharyngeal, Large, Adult | 1 | |
| Thermometer, Clinical, Human, Oral | 1 | |
| Scissors, Bandage, Angular, 7½ in. | 1 | ✓ |
| Pins, Safety, Curved, Orthopedic Med 12s | 1 Package | |

Appendix A Continued

| Item | Quantity | Used in EMTS |
|---|----------|--------------|
| Surgical Instrument Set, Minor Surgery | 1 Set | |
| Pencil, Mechanical | 1 | ✓ |
| DD Form 1380, U.S. Field Medical Card | 2 Blocks | ✓ |